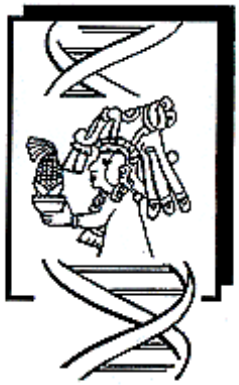
Scientific Basis of Participatory Plant Breeding and Conservation of Genetic Resources



Bases Científicas del Mejoramiento Participativo y la Conservación de los Recursos Genéticos

Oaxtepec, Morelos, México

8–14 October 2000

Linking theory with practice in…

…Genetic resource management
…Biodiversity conservation
…Plant breeding
…Biotechnology
…Economics and marketing
…Social contexts
…Case studies

…to meet rising global food needs while conserving genetic diversity and increasing economic well-being of farmers

Abstracts

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Strengthening of community management for agricultural biodiversity: A way to implement the Global Plan of Action for Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture

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The sustainable management of plant genetic resources and other aspects of agricultural biodiversity by farmers and their communities, is a prerequisite to achieving sustainable food and livelihood security. The Global Plan of Action for Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (GPA) adopted by 150 countries at the Fourth International Technical Conference on Plant Genetic Resources at Leipzig, Germany in 1996. The GPA recognized the important role played by the farmers and their communities in the national plant genetic resources for food and agriculture (PGRFA) programs. Countries committed to carryout this GPA in cooperation with all stakeholders. FAO is promoting and catalyzing the implementation of the priority activities of the Global Plan Action through technical assistance and support to countries in identification, development and implementation of specific activities of interest to national programs. The GPA includes a priority activity, "Supporting On-farm Management and Improvement of Plant Genetic Resources". This activity aims to strengthening of community management of agricultural biodiversity. FAO using gender sensitive participatory approaches, drawing up the experience of "Farmer Field Schools" for Integrated Pest Management projects and other relevant approaches such as "seed fairs", participatory plant breeding activities assisting a few countries in the implementation of GPA activity on on-farm management and improvement of PGRFA. The paper will provide detailed information on the Global Plan of Action including FAO activities in its implementation, in particular, activities related to community management of PGRFA.

Participatory plant breeding and community property rights: Developing access and benefit sharing community protocols for agrobiodiversity in the Andes

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There are fundamental philosophical differences among indigenous peoples and non-indigenous stakeholder on the debate regarding access, benefit sharing and the protection of indigenous knowledge. While most non-indigenous actors see access to and benefits from traditional knowledge as an economic right, indigenous peoples believe that their knowledge cannot be separated from their cultural values and fundamental rights to self-determination, land and territories, self-development and environment protection. Participatory Plant Breeding is one example of a situation in which the flow of knowledge from local farmers and indigenous peoples to scientists and "experts", raises the issue of how to develop appropriate systems for the protection of community knowledge.

This paper presents the views of ANDES on establishing community property rights systems, which may be utilized for the protection of community knowledge in situations such as Participatory Plant Breeding projects. The community protocol, whereby communities articulate their needs and define their own rights, is presented as an alternative to strengthen local rights and to preserve local people's knowledge and associated biological resources. The use of such protocols, which are built on customary laws and established within the local values system, ensures that the benefits derived from the use of the local indigenous knowledge flow directly to the community.

Of participation in participatory plant breeding: An analysis of two common assumptions

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Participatory plant breeding (PPB) refers to a range of approaches that involve users more closely in crop improvement and seed supply. This presentation examines different modes of farmer involvement in PPB to analyze two common assumptions: a) more participation is always better, and b) participation benefits the poor. It argues that while participation generates benefits to farmers, it also entails costs and trade-offs. Therefore there are optimal levels of farmer involvement. In PPB these optima may be a function of the crop and its biology, the traits of interest, the farmers and their characteristics, the agroecological environment and its heterogeneity, and the scale of the PPB effort. There may be an inverse relationship between the scale of the effort and the level of farmer involvement. Furthermore, at any scale the costs of participation to the poor may increase more rapidly than to other groups. They may have less time available, less ability and willingness to take risks, lower education levels and in many cases more precarious health. The poor may derive lower net benefits from modes of participation that require high involvement. Therefore, modes of participation with limited levels of direct farmer involvement may be the way to reach and benefit large number of poor farmers. The most cost-effective forms of engagement need to be identified from case studies. An example from Oaxaca, Mexico is presented to show how to make operational the research issues derived from this analysis.

Linking participatory plant breeding to the seed supply system

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There is a strong link between conventional plant breeding and formal seed supply systems. In developed countries, it was the emergence of organized plant breeding based on genetics that generated new named varieties and stimulated interest in their organized multiplication and marketing by seed companies. In developing countries likewise, the experience of the 'Green Revolution' in the 1960s promoted interest in national seed projects and programs which could deliver the products of plant breeding more effectively from breeder to farmer. The provision of a secure conduit from research into agriculture remains a major justification for formal seed activities.

The limitations of conventional breeding have been recognized in recent years, especially for crops grown in marginal environments, where farmers' requirements are more complex. This has prompted interest in alternative breeding strategies in which farmers can play a much more active role in the selection process. There has been a parallel recognition of the role of the informal seed sector, as the major seed supplier in many crops and areas in which the regular sale of seed by formal organizations is difficult. In reconciling these trends, the key question is—"How do participatory breeding approaches relate to both formal and informal seed systems?" This paper examines the technical and regulatory aspects of this question, with emphasis on the following issues:

- The nature and definition of PPB outputs,
- Maintaining the identity and integrity of PPB outputs
- The relevance of official variety evaluation and registration system,
- Maximizing the diffusion and impact of PPB outputs
- Innovative seed supply systems linked to PPB activities
- The role of national seed policy in facilitating alternative seed delivery systems

The synthesis of this discussion is that PPB initiatives must be linked to a secure diffusion strategy within and beyond the participating communities if the technical and social benefits of this approach are to be fully realized. National policies relating to seeds and regulatory frameworks must also take account of this approach to avoid downstream constraints.

Participatory plant breeding—Does it achieve or does it compromise genetic conservation?

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Participatory plant breeding (PPB) is a fresh approach to the challenge of improving crops in marginal areas, that links the local needs and knowledge of the farmer with the breeding expertise and resources of the formal sector. Under PPB, both the farmer and breeder share the selection in segregating populations from the earliest stages. From the standpoint of conservation, PPB has been advocated as a way to maintain or even enhance the level of genetic diversity deployed on farm. The proposal is that PPB can breed divergent cultivars for environments that differ on a fine-scale, and for diverse uses; and that PPB adds value to traditional landraces that would otherwise face eclipse. On the other hand, the success of the products of PPB may stem from the addition of just a few major genes (e.g., for pest resistance or plant height). Their inclusion into some local lines may swamp a significant fraction of local diversity, leading to a short-term gain in productivity, the loss of local unimproved populations and increased vulnerability. PPB is so recent that its impact on the conservation of crop biodiversity is unknown. The plant mating system is a crucial parameter that affects the predicted outcome of changes in crop improvement system. Thus selfers such as barley and rice in isolated or marginal areas may have landraces closely adapted on a fine-scale and the switch from traditional populations to PPB effectively increases gene flow. On the other hand the maize system is relatively open with high levels of seed exchange, and a switch to PPB may require more efficient mass selection and less gene flow, both of which can lead to less diversity. It will be important therefore, as an adjunct to PPB schemes, to define conservation concerns, delineate the research needed to test those concerns and have a strategy to meet them.

Plant improvement: Theory and application

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Plant improvement has always been an important goal of human civilizations. After the potential of plants to provide food, fiber, fuel, and feed was realized, humans have emphasized plant improvement to provide a more secure supply of plant products to meet their daily needs. The initial methods of plant improvement were based on individual plant differences. The genetic basis of the differences among individual plants was not understood, but the early methods of plant improvement developed more productive plants from their wild, weedy ancestors. The early plant breeders developed the germplasm resources for plant improvement during the 19th and 20th centuries. Modern plant improvement methods are based on the concepts of Darwin and Mendel and subsequent principles of biometry for more complex traits. Identifying elite genotypes and intercrossing elite genotypes for continued selection are the basic tenets of plant improvement for greater productivity, greater pest tolerance, and greater stability of productivity. Recycling is the basic feature of plant improvement, whether for the simplest methods of mass selection or for the more complex methods of reciprocal recurrent selection. With a greater understanding of the genetic basis of the inheritance of plant traits, selection methods were modified to emphasize the genetic differences among plants and their progenies. Effective

screens were developed to identify superior cultivars for the target environments. Present methods of selection are equally effective to develop improved cultivars for small, subsistence producers and for large producers using the more advanced methods of production. Effective methods of plant improvement are necessary to develop improved germplasm sources and superior cultivars to provide adequate food supplies for the predicted increases of the world's human population.

Linking genebanks and participatory conservation and management

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The complementarity of *ex situ* conservation and *in situ* conservation on-farm of crop genetic resources is often stated. To develop this complementarity and limit the duplication of efforts and waste of resources, links have to be established between these two approaches. The global mission of genebanks, preservation and distribution of germplasm and related information, must meet the more local needs of participatory conservation and management.

A case study on rice genetic resources in the Cagayan Valley, Philippines illustrates some of the advantages and difficulties in developing such links. The flow of germplasm and knowledge—in both ways—between gene banks and local conservation benefits to all stakeholders by improving the biological and socioeconomic knowledge of the local diversity. From a practical standpoint, the *ex situ* conservation of local diversity may require conservation and evaluation approaches at scales that differ from those usually adopted by gene banks. Gene banks also need to develop their ability to help restore the local on-farm diversity in emergency cases. On the other hand, the involvement of local stakeholders in the conservation and management of non-local genetic resources must be considered as a possible option.

A role for the private sector in participatory crop improvement

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Abstract available at Symposium.

The organization of farmer seed systems: Relevance for participatory plant breeding

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This paper examines the organization of variety selection and seed production among the farmers who might be targets for participatory plant breeding (PPB). Although local seed systems are admirably diverse and adaptive, they also exhibit a number of weaknesses. The discussion pays particular attention to the incentives, information management and resources applied to maintaining local seed systems and points to deficiencies that may limit the scope of PPB. In particular, the analysis calls attention to the challenge of addressing farmers' diverse interests and resources, the uncertain incentives that motivate the local agricultural economy, the effects of imperfect information, and the limitations of inadequate seed diffusion mechanisms. The paper concludes with a brief examination of how PPB can encourage local farming systems to press for more effective political and market representation.

Community "management" of diversity

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We often perceive economic development as a threat to the historic association between agricultural communities and crop landraces. Subsistence-oriented farm households maintain a repertoire of varieties to meet their consumption needs, protect against income and consumption risk, and as a response to various market constraints, including limited access to funds to purchase staples or invest in new income-earning activities. However, development presents the opportunity to satisfy most household needs and constraints through markets, opening the door to agricultural specialization. Some studies argue that there are cultural reasons for households to preserve diversity, but how market development may influence cultural incentives for crop diversity has not been explored. In theory, markets may create incentives either to conserve or reduce diversity. Numerous recent studies suggest that, indeed, households with better access to markets maintain less crop diversity than more isolated, subsistence households. Thus, the current expansion of world and regional markets raises concerns about crop diversity. In this paper, we argue that understanding how markets affect diversity requires a research focus that transcends individual households and views markets as community and regional institutions with dynamics of their own. Drawing from research in the Sierra Norte de Puebla and other areas, we explore the implications of market development and discuss the appropriate role of economic research in crop genetic resource conservation.

Training farmers: A useful tool for the on-farm conservation of maize

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Farmers have extensive knowledge of agricultural matters. However, there are many aspects they are not aware of or do not fully understand. Filling in those knowledge gaps is a powerful way to empower them and improve their welfare. As part of a larger project for on farm conservation of maize in the Central Valleys of Oaxaca, we organized a set of training activities for farmers on principles and techniques to maintain or improve characteristics they value in their maize landraces. Both male and female farmers were invited to attend group meetings where we elicited and discussed their knowledge and views on maize improvement. Results showed that they have a limited understanding of this issue, leading us to design a course to train them in these topics. Three sessions were organized.

The first was a "classroom" training in which we introduced and explained a set of basic principles. The second was held in the field during flowering to train participants in identifying desirable and undesirable plant characteristics. The third session, which was also held in the field, provided training in selecting plants and ears with desirable traits for seed under full competition. Through this training, farmers gained new insights into maize reproduction such as the role of parents, offspring, and inheritance, as well as hands on experience with field practices for seed selection and storage. Although it is early to see major results, we have observed that already five farmers have selected their seed in the field taking into account plant characteristics. A few farmers tried detasseling to mark plants, some to see whether the plants will survive, others to eliminate undesirable plants, and some just to see what happened. Six farmers want to mix, or already have, the introduced materials with their own materials, for planting the next season.

Use, management, and preservation of quelites (greens) in Naupan, Puebla

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Quelites are herbs, whose leaves, stems and immature inflorescence are edible. They generally grow in anthropogenic environments and they constitute important potential resources. The objectives of this study are to establish the relationships between the consumption, frequency and management of the different species of plants used under the name of quelites (greens), as well as to know the preservation level of them in a community of the Sierra Norte of Puebla, Mexico.

Naupan population recognizes under the name of quelites (greens) 35 different species of plants (a high percentage of the 80 different species reported for the Sierra Norte of Puebla). The inhabitants obtain quelites (greens) for their consumption into town for sale and through their collection in several habitats (i.e., milpas [corn fields], coffee plantations, fruit or vegetable gardens, primary and secondary vegetation). In order to know the use and management of quelites (greens), the following actions were performed: open interviews, structured interviews and ethnobotanic collections. The methodology employed, trying to find out the frequency of consumption of quelites (greens) was the 24 hs. recall. This technique was applied each month during one year to a sample randomly assigned, consisting of 47 families. The sample corresponds to the 19% of the population. Finally, field-work was performed in order to know the abundance and preservation of quelites (greens) of less consumption.

The results are the following: from the 35 species of quelites (greens), 7 are frequently consumed, 5 of them are regularly consumed, and 23 are occasionally consumed. There is a relationship between consumption and management, since the most consumed species are cultivated, tolerated or promoted, in general. This study presents some clues regarding the use, management and preservation of quelites (greens).

Conservation *in situ* and improvement of milpas in the Sierra Norte of Oaxaca, Mexico

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Oaxaca is one of the centers of origin of many plant species, such as: maize, beans, squashes and chilies, among others. In addition, it has 16 indigenous groups distribute across the state, groups who possess a great cultural wealth in practices of cultivation, knowledge of useful species and different uses. The Sierra Norte of Oaxaca is inhabited by the Mixe, Mazateco, Cuicateco, Zapoteco, Chinanteco, Mixteco, and Nahuatl indigenous groups who practice the "milpa" system which maintains high levels of genetic variation and have provided a stable production of food and other products. Nevertheless, the demand for food has increased in recent years due to the rapid increase in population, which also has created pressure on the natural resources, requiring improvement of yields and conservation of the species of the system. This project seeks the conservation and improvement of the genetic wealth of the milpa system with active

participation of the Mazateco, Cuicateco, and Mixe indigenous groups of Oaxaca. As a result of our initial research, we were able to collect 234 samples of maize (115 white, 92 yellow, 14 black, 16 pinto and one red in color), 64 of beans (12 bush and 52 pole types) and 30 types of squash. It was interesting to observe the great diversity of varieties kept by the regional producers. On the average, each producer works with 1.9 types of maize, 1.6 types of beans and 1.9 different squashes. As a result of the evaluation and characterization of the maize collections, six diverse genetic groups were found. The maize races found were: Olotón, Comiteco, Nal-Tel of tierra fría, Serrano, Bolita, Cónico, and introgressions of Conejo, Pepitilla, Celaya, and Chalqueño. In beans, we found wild and cultivated species of *Phaseolus vulgaris* and *P. coccineus.* Then, from the study of squashes, we found 12 collections of the species *Cucurbita pepo*, five of *C. moschata*, two of *C. angyrosperma*, and 11 of *C. ficifolia*. In the evaluation plots, five field demonstrations were carried out with producers for selection of the most promising materials. Also, 160 local farmers were trained in the techniques of conservation and improvement of the milpa.

Maya maize farmer's varieties and genetic diversity

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The International Plant Genetic Resources Institute (IPGRI) project "Strengthening the scientific basis of *in situ* conservation" is devoted towards the enhancement and support of a framework of knowledge on farmers' decision-making processes that influence *in situ* conservation of agricultural biodiversity. Through strengthening the national institutions for planning and implementation of conservation programs involving a much wider group of actors and stakeholders-farmers, communities, universities, research centres, and other groups for broadening the use and participation in the conservation of agricultural biodiversity.

The México project is located in Yaxcaba, Yucatán region where the maize, bean, squash and chili peppers crops were investigated under slash and burn system. An ethnobotanical study was focused on building a diagnostic of the biodiversity on-farm in which was included social data of the community and cropping system. The farmer perception of maize landraces were recognised and tested with agromorphological characterisation plots. Also, an isozymic characterization of these varieties were made in the molecular markers lab of the Colegio de Postgraduados in Montecillo, México.

Farmers classify maize by growth cycle, which ranges from seven weeks to four months from planting to flowering, and by grain colour, both of which are reflected in Mayan maize landrace names. Fifteen varieties of maize were recorded among 100 accessions collected by the first ethnobotanic diagnostic. Seven varieties correspond to the Tuxpeño (*Xnuc-nal*) race, two to the *Nal-tel* race, two to the *Tsiit-bacal* race and four to types that are thought to be intermediate between Nal-tel and Tuxpeño, coinciding with *Xmejen-nal*.

It was noted that local varieties vary greatly in length of growing period because farmers consciously select maize with different growing cycles in order to protect themselves against the uncertainty of climatic conditions and the urgency of the availability of grain. Farmers tend to plant maize with long cycles to the upland areas with extremely stony soils, whereas the early maize varieties are planted on the small areas of level ground of organic soils in home gardens. The grain colour is associated with the necessity to vary the colour of food types of (tortillas, tamales, pozoles, sopas, atoles, elotes, etc.).

Participatory plant breeding in the Bean/Cowpea CRSP: A case study

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The Bean/Cowpea Collaborative Research Support Program (CRSP) is a program funded by USAID that brings together scientists from Host Countries in Africa and Latin America to work with scientists from Land-Grant universities in the U.S. on bean or cowpea research and training. From the beginning, several of the country programs of this CRSP have had social scientists participating with the biological scientists in attempts to generate the kinds of information that will help breeders develop plant material of interest to the farmers and consumers, support genetic diversity and reinforce the strength of the national research and extension programs. Set in the historical context of the prevailing development thinking of the day, this case study highlights three of the projects of the program that have directed attention to the participation of farmers in their breeding efforts to varying degrees. The three models of farmer integration described are the Malawi model, the Tanzania model and the Honduras model. The author considers the leading approach to participatory research currently in vogue (Participatory Action Research) and asks how far must technical scientists go in the direction of empowering farmers to address social and economic as well as agricultural constraints in order for them to be able to benefit in large numbers from the technologies generated.

Scope and basis of rice improvement through the use of indigenous conservation knowledge in Bangladesh

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Bangladesh is located in South Asia, between 20. 35º N to 26.75º N latitude and 88.03º E to 92.75º E longitude that is favored to grow a wide range of tropical crops year round. Rice is the principal crop and covers 80% arable land

planted to field crops. There are four distinct ecotypes of rice—Boro, Aus, Transplanted aman, and Deep water aman. These have been identified by the farmers, based on ecology, use, crop duration, and cultural importance. This system also enhances conservation of diverse varieties under varied ecological system and involvement of ethnic groups of farmers. The four ethnic groups in Bangladesh are Dravidian, Proto-Austroid, Mongoloid, and Bengali.

The use of diverse cultivars and *in situ* conservation and on-farm management has helped diffusion of indigenous knowledge among the communities and ethnic groups. The vernacular names have been developed by the communities through observation and perfected by trial and error. These criteria are disease reaction to the particular variety, crop duration, photosensitivity, aroma, grain and cooking quality, market demand, preservation, and fermentation. For example, Rajbhog (King's dish), Saita (Sixty days), Rajmukut (Errect panicle), Khejur jhupi (Clustered grain), Nonia (Saline tolerant), Bawalia (Deep Water), and others.

The indigenous knowledge and scientific findings of these traits have had a unique correlation and validation. This conservation system and indigenous knowledge can be used in scientific use of desirable gene(s) of interest. This knowledge could also go a long way to integrate gene(s) from different ecotypes/varieties for developing value-added seed/variety through biotechnological techniques.

Genetic structure among natural populations of *Maytenus ilicifolia* (Celastraceae) through RAPD markers in state of Parana, Brazil

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Maytenus ilicifolia is a shrub with natural occurrence in ombrofilous mixed forest (i.e., forest with *Araucaria*). This species has popular use as a cure for stomach illness in community knowledge of the indigenous people from Brazil. The fragmentation of the forest with *Araucaria* in previous years, together with the therapeutic use on a large scale, had caused much devastation of its natural populations. This resulted in the loss of the genetic complex of this medicinal resource. There is an urgent need to initiate studies to elaborate strategies of conservation and domestication of this germplasm. The goal of this study would be to estimate the genetic structure in natural populations of *Maytenus ilicifolia* in State of Parana (Brazil) through polymorphism of RAPD markers.

The areas of study are located in Lapa City where there exists one population and two populations are to be found in Guarapuava City. Theses areas are geologically diverse and under different landscape domestication. The key first step is to analyze the plant DNA fragments, in order to purify the quantity and quality for use during the process. The DNA extraction would be carried for leaves in adult individuals. Seven primers of RAPD were selected which produced 52 markers in *Maytenus ilicifolia*. After interpretation, the genetic distance among the three populations were obtained. The data show that the four main groups in the three populations studied were distinct. The results open prospects for future molecular study. They also provide us with an opportunity to elaborate models in management of medicinal biodiversity through the establishment of collection strategies.

Valuing native potato diversity for exceptional post harvest qualities

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Improving the productivity and sustainability of agriculture, and the livelihoods derived from it depends on the conservation and valorization of genetic resources in the context of their use. CIP's effort to reinforce the on farm conservation of native potatoes in Peru seeks to enhance the security and value of traditional varieties to farmers, through a series of participatory approaches. Understanding the value native crops hold for farmers and the ways social roles and technological options affect these values is among our underlying concerns. A mosaic of varietal, social, and motivational patterns for maintaining diversity have been documented in the process of establishing community gene banks in microcenters of genetic diversity of Andean potato cultivars. While farmers and farm families recognize both *option* value (represented as ancestral bequests of materials and skills) and *direct* value (flavor, texture, cooking and food use parameters) in their subsistence production of potato variety mixtures, interest in access to markets is increasingly encountered. Fortunately, several of the most appreciated post harvest characteristics of these farmer varieties also make them suitable candidates for new uses linked to changes in lifestyles and dietary habits, to which processing industries are responding with snack- and fast-foods. Following a survey of 175 varieties, a set of preferred and predominant cultivars was selected with the Aymara Community and evaluated for potential use as raw material for potato chips. Several of these were found to be uniquely robust to production and storage conditions that are usually adverse to chip quality, and their absorption of less oil in frying relates well to both economic and health concerns. Combined with their excellent flavors and attractive colors, the varied shapes and pigmentation patterns of native varieties result in products with considerable novelty appeal. Considering the substantially different bases of the values accorded to household and commercial potato plots, and diversity *per se* by Andean farmers and communities, it is not expected that new market opportunities will result in the erosion of on farm diversity. Rather, such added value might provide complementary incentives for the conservation of valuable biodiversity and indigenous knowledge through sustainable use in changing times.

Ethnobotany and the economic role of four species of quelites (greens) in Tuxtla, Zapotitlan de Mendez, Puebla, Mexico

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The present study is an approach about the knowledge, use and management, as well as the way of taking advantage, of four different species of quelites (greens) in a Totonaca community in the Sierra Norte of Puebla, Mexico. Ethnobotanic information was gathered through open interviews, direct and participatory observation, botanical collection, visits to marketplaces and the follow-up of 10 production units during the agricultural cycles. In this way, the economic contribution that quelites (greens) represent to the population, could be established. In order to know the nutritional value that each of the different species of quelites (greens) represents to the regular diet, a proximal bromatological analysis (in minerals and vitamins), was also performed. The results show that the management and the taking advantage of quelites (greens) is integrated and it is directly related with the biological cycle and the production of the main crop in which they grow. It represents 15% of the total profit in an agricultural cycle, allowing in this way the maintenance of biodiversity, a more temporal and spacial use of the plot, as well as an alternative of production in case that the main crop does not succeed: They contribute in the variety and complementation of the peasant's diet, since this is an important source of vitamins and minerals.

Interdependence of *ex situ* and *in situ* conservation

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Crop landraces are considered by some to have superior local adaptation over modern-day crops, and may be preferred by local communities. Furthermore, landraces have persisted for a long time, but it does not necessarily follow that they will persist in the future. In the field, genetic truncation does occur, and loss of valuable alleles represents opportunities foregone for breeding improvement for increased food production. In this paper, two examples of loss of diversity are considered: firstly, the vulnerability of field-maintained conservation, and secondly, loss of desirable alleles through modern plant breeding practice.

The Crop & Food Research (C&FR) world wheat landrace collection was sourced in 1928 by the late Sir Otto Frankel from the Plant Breeding Institute, Cambridge, England. It consists of 2000 pure-line samples of landrace ecotypes, historically maintained over a three-year field-regeneration cycle, until improved genebank facilities were established in 1986. Field-sown samples were "backed-up" by a reserve spike which, for many years, provided good insurance against loss. However, stripe rust (*Puccinia striiformis*) was introduced to New Zealand in 1986 with catastrophic effects on survival rates within the collection. All "super-susceptible" varieties were lost. For poorly outcrossing species, such as the small grain cereals (wheat, barley, oats), this loss of genotypes illustrates the vulnerability of *in situ* conservation.

Modern plant breeding practices are also responsible for genetic truncation of potentially useful alleles. This truncation was demonstrated by comparing the diversity of wheats currently in world commerce with that of the C&FR landrace collection. Specifically, when storage protein alleles were screened, the C&FR landrace collection displayed a doubling of the known number of allelic variants compared to the modern-day crop. Because *in situ* conservation is a poor preservation strategy, gene banks are needed to provide germplasm for conscious breeding improvement. Conversely, because of regeneration difficulties, gene banks can do little to preserve the genetic integrity of complex landrace varieties. Therefore, traditional ecotypes need to be maintained *in situ*, so that their components can be studied and duplicated through breeding and selection to include desired genes for increased productivity.

Analysis of genetic diversity in oca (*Oxalis tuberosa* Mol., Oxalidaceae) using RAPD molecular markers

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Genetic diversity in 19 varieties of oca (*Oxalis tuberosa* Mol.) was estimated using the Random Amplified Polymorphic DNA (RAPDs). A sample population of 19 varieties (morphotypes) of Oca from the Peasant Community of Picol, in the distrit of Taray, Province of Calca, in Cusco, was used. According to RAPDs markers, these samples of Oca showed poor diversity. A prior primer screening was done using 96 primers decamers from which seven primers were selected as the most informative. These 7 primers amplified 53 reproducible fragments, ranging from 377 to 1798 base pairs; since 19 fragments were polymorphic, the population showed 36% of polymorphism. These genetic markers allowed to distinguish only the morphotype B, as the most polymorphic (22% of similarity) within the population. The dendrogram derived, grouped the population into three main clusters. The prior 96 primers screened produced 373 reproducible fragments, ranging from 377 to 2445 base pairs; being a RAPD primer database of a total of 364kb of oca genome amplified, which represents 0.1% of Oca genome size, according to the preliminary estimation of 3.80 pg (Emshwiler, 1998).

Role and participation of women in the process of *in situ* conservation in Burkina Faso

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The methodology of *in situ* conservation is currently in full experimentation stage in Burkina Faso. To evaluate the true nature of participation of women in the process of *in situ* conservation, a study has been established with the assistance of IPGRI. In this study 89 women and 27 men (Mossi, Bixa, Samo, Peuhl) from four villages (Médéga, Ouahigouya, Gourga, Pobè Mengao) have been surveyed. Individual and focus group interviews have been conducted. Collected data are completed by direct observations in fields, granaries, markets, places of transformation, etc.

The women are involved in the process of *in situ* conservation at several levels:

1) Women of Burkina Faso working on the farm devote more than 70% of their time to the following tasks. Women intervene in ploughing (30 to 45%), seedling (95%), weeding (40%), transportation of products (45%), shelling (90%), and storage (80%).
2) In some regions, according to their age and social rank, they intervene equally in the selection, distribution, exchange and conservation of varieties in the village and its surroundings.
3) In the processing sector, women constitute the majority (more than women process 95% of farm products). The women increase the value of agricultural products.
4) The retail sale of varieties is 100% ensured by women, whereas the wholesale trade is carried out both by men and women.

Women know and respect conservation rules: plants that serve to preserve seeds, the types of the granaries to be used, bottles, manner of conservation and good lunar periods for doing these activities. The women guarantee traditional practices and ensure these are passed on from generation to generation.

Women, especially in the Bixa of Médéga (village), have a large say (or have power) in the decision making process for the selection of varieties for planting of sorghum, pearl millet, ground nut and cowpea. For okra, only women select, maintain, and exchange varieties. On the other hand, in all villages surveyed, seeds of "frafra" potatoes are selected exclusively by men. Women of Burkina Faso take care of the demands made by social/tradition, the environment and the economy through their commitment and their know-how. They derive direct and indirect benefits (money, protection of the environment, food security) from *in situ* conservation.

Land distribution and crop allocation at the village level: Breeding, conservation, and welfare

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Studies of households' management of landraces have usually eschewed land issues, such as its distribution among households within a community. This distribution is a determinant of crop genetic diversity at the regional level through its effect on land allocation among crops and crops' landraces. Hence, land must be treated explicitly at this level, particularly if soil and climate limit the spatial distribution of landraces. Land changes hands through inheritance and sale, and temporarily, through rental. But even temporary changes can alter gene frequencies when seed cannot be conserved without replacing. Breeding programs must anticipate their effect on land distribution to achieve their welfare and conservation goals. Programs can also employ land redistribution as an instrument.

We chose the town of Zoatecpan to learn how an indigenous Mexican community manages its land, and its neighbors' land, in the Sierra Norte de Puebla. Zoatecpan's agriculture is milpa (corn/beans/squash), planted almost entirely to landraces. Analysis of our data shows that since milpa is often unprofitable, large landowners parcel out their land among smaller ones, bringing a more progressive use of the land to Zoatecpan. Over 50% of milpa is grown in rented land. Households grow milpa for self-consumption, to employ their labor fully, and to hedge risks. Their willingness to rent is frequently limited by debt and low income. Changes in landrace diversity across 1998–2000 were driven entirely by the redistribution of land through rental. Yield improvement through breeding will affect land distribution by increasing milpa's profitability. We describe how its effects on i) household welfare and ii) landrace diversity depend on the association between the decision to rent and the choice of landraces. Overall, since rental prices are bound to increase with yield, breeding might deprive poor households of land. These effects can be countered through income-transfer and staple-price policies. We suggest further research questions.

The market for specialty corn in the Sierra Norte de Puebla: Its current state and prospects for change

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Crop landraces are frequently preferred by consumers for their culinary qualities. The price premium that these qualities can command in the market has theoretical implications on these varieties' ability to survive the integration of mar-

kets and economic development in general. Since a price premium can increase the competitiveness of local producers over foreign ones with lower production costs or higher yields, it was thought that a premium would buffer Mexican corn producers from NAFTA. It is currently thought that a price premium may protect corn landraces from displacement by locally grown improved or high yielding varieties, or by imported grain. The argument rests on the assumption that as the market for corn integrates, markets for specialty corn will develop.

We look at a region in the Sierra Norte de Puebla, Mexico to learn the current state of the corn market, and the prospects for change. The study region includes temperate and tropical areas holding different agricultural regimes. Milpa (corn/beans/squash) is dominant in the former, but shares land use with coffee in the tropic. Although regional landrace diversity is not well documented, some corn landraces are restricted to either the temperate or tropical areas. Corn landraces are preferred by most consumers and generally command higher prices. Local commercial and subsistence households supply landraces, but most corn sold in the market is imported by private and co-op retailers. Despite a generalized corn deficit, the temperate area supplies, and the tropical area demands landraces in the regional market, so further specialization could endanger tropical landraces. We study the determinants of supply and demand for landraces in the temperate and tropical areas, and tie them across areas to understand how changes in income, prices and migration might affect the development of this market.

The Nalxoy maizes from the traditional Yucatecan milpa

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Since 1983 peasant families at Xoy town, Peto County, located at South Yucatán, México have been improving and diffusing to other areas the maize landrace known as NalXoy or "maize from the Xoy town" under the leadership of the Chi-Canul family. Based on an empirical method, this family obtained productive populations of the NalTel race and PR-7822 (an improved form of the Tuxpeño race). The latter appeared to be a good choice because of its high yield. However, it had poor storage properties and was susceptible to pests. To overcome these deficiencies it was decided to cross both populations.

From the segregates of the NalTelxPR-7822 crossing, a group of populations were selected by plant height, cane resistance, kernel yellowish, yield, and resistance to storage plagues and pests. The selected group of materials and its use have been distributed in a traditional way by government programs and research projects. Thus, accomplishing a diffusion of the seeds in the peasant communities of South and Center Yucatan State and part of the Mayan area of Quintana Roo State. By 1988, the Chi Canul family began to select white kernel ears in order to get a production of early corn. By 2000, a production of ears in early sowings was obtained.

Gene flow, effective population size, and mating systems: A complex genetic braid

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In this study we review the different theoretical and empirical issues related to the study of gene flow in natural and managed plant populations. Even though gene flow seem to be clearly defined in textbooks, in practice is difficult to disentangle it from the effective population size, pollen and seed dispersal and from the other aspects of plant mating systems. We discuss the methods proposed for the genetic study of these evolutionary processes using different genetic markers. We analyze these methods and ideas using four studies.

First we exemplify the problems of separating mating systems, pollen and seed dispersal, effective population sizes and gene flow using detailed data from the populations of the tropical rain forest palm *Astrocaryum mexicanum*. In this species we used several different ecological and genetic methods, and we compare our approach with others used in different plant species, both from natural and cultivated populations. Our second example is our evaluation of the advantages and problems of different indirect methods for studying gene flow and effective population sizes in four very closely related species of firs (*Abies*) using 33 populations from southern Mexico. In our third example we illustrate the relationships between the reproductive ecology, morphology and the genetic structure with *Agave lechuguilla* in a latitudinal gradient that included 11 populations in the Chihuahuan desert. Finally, we analyze the relationships between ecological and genetic estimates of gene flow within and among species in a study including wild and cultivated *Cucurbita* taxa from Jalisco, Mexico. From these examples and others from the literature and from our laboratory, we propose that the relevance of the different processes related to gene flow, within and among populations and between species, can be studied with similar ecological and genetic methods both in natural and in cultivated populations, either managed traditionally or by using modern technologies.

Farmers' participation in the evaluation and selection of cassava varieties

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This work had the objectives to present and to discuss the results of the first evaluation and selection of cassava varieties with the farmers' participation in the semi-arid of the Brazilian Northeast. The participatory research method was used in the cassava improvement with farmers in the evaluation and selection of new clones offered by the research in-

stitution. This method is based in the largest integration among researchers, extension and farmers in the program on cassava breeding. The farmers participated actively in the whole process of evaluation and selection of cassava varieties and they emitted theirs opinions on the main criteria for variety selection. In the years from 1994 to 1997 twenty two participatory tests was established on the farmers' fields located in the semi-arid of the states of Bahia. The tests were installed with nine clones of cassava, including a local variety, in plots of 50 plants per clone, without repetition, and followed the traditional cropping system of each grower. The probability of acceptance of each clone was determined through the curves of logistical regression estimated as the accumulated probability of preference for each clone and the order of preference for each one. Some varieties presented high probability of acceptance by the farmers. Modified stability analysis adapted for farmers' tests was used. A curve of regression was obtained for each clone by using an environmental index, calculate as a production average for all varieties in each environment and the yield average for each clone. The farmers' participation in the evaluation and selection of the cassava varieties, generated by the research, was fundamental to identified the farmers' selection criteria, elevate the levels of the adoption and diffusion of the new improved varieties, and consequently, to generate the expected impacts for the use of the new technology.

Participatory research on cassava breeding in Brazil

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This research gives a brief history of the introduction and the progress of the participatory research in cassava breeding in the Northeast of Brazil developed by EMBRAPA Cassava and Tropical Fruit Crops. This methodology was initially developed by the International Center of Tropical Agriculture (CIAT), in Colombia. Further, in 1993, the participatory research was introduced and adapted to the semiarid conditions and expanded for other conditions of the Brazilian Northeast. The objectives were to elevate the levels of adoption of the improved varieties, the feedback of the programs of cassava improvement with the farmers' criteria and to enlarge the genetic diversity of cassava farmers. The research was done on-farm, in a process whereby farmer participatory in the entire process from evaluation and selection of clones on preliminary and advanced phases of selection, design of cultural practices for their management and interaction with a extension technicians. The results reveal that the methodology of the participatory research with cassava varieties, as a complement to the conventional method of genetic improvement of the crop, is perfectly adapted to the cassava farmers of that region. The process works functions as an efficient tool for the transference and diffusion of the selected varieties as well a feedback for the cassava improvement programs with the farmers' criteria selections. Some impacts of this work have been the immediate adoption of new cassava varieties, the increase of the genetic diversity of the crop in that region, and the quality of the technicians training in that methodology. It was conducted that with new focus, the cassava improvement in the Northeast can generate new impacts, originated from the adoption of the new varieties, contributing in a more effective way to the development of the cassava agribusiness in the Northeast.

Participatory genetic improvement of corn (maize) in central Veracruz

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Coffee has been the main income of the peasant, as well as of the important urban sector in central Veracruz since the 1970s when a spectacular increment occurred.

Previous to this period, the regional coffee production was more diversified including corn, bean and some fruit trees within each ecosystem. However, much of the land-area devoted to these crops was replaced by coffee plantations. This led to a strong economic dependence on coffee and the consequent loss of some local corn varieties. But due to the continuous fluctuation of coffee prices in the international markets to which poor peasants are more vulnerable, the latter continue sowing corn to generate a steady income and food supply. In 1993, a project of plant breeding with land races of corn was started to support this survival production strategy. The objective of this exercise was to assure the peasant family a staple supply of corn. In the first phase 12 land races of improved corn, using crossing over method of Márquez (1990) were used in this study. Five genotypes were used as donors to eliminate non-desirable traits determined by local peasants, such as short size and resistance to "acame" (plant toppling over due to disease or lodging). After four seasons, i.e., in 1997 the seed was given back to the peasants for sowing for using the mass selection procedure for improvement.

A partial evaluation of the participation of the peasants in the process shows positive results. From 28 households, 16 of them sowed corn with the proposed methodology, and they continued selecting their new seed by using the proposed methodology. The remaining 12 peasants did not show interest in the proposed methodology and they still continue their own method of corn breeding in the granary rather than at the field. Beyond these results there is a multiplier effect. As many as 30 non-participating peasants have acquired seed though farmer to farmer exchange. Finally the new selected genotype showed 30% less plant height than the land races and increased yield. However they still have flaws like ear rotting and cob thickness.

Farmer-based tetraploid wheat landrace improvement—The Ethiopian experience

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Durum wheat (*Triticum durum* Desf.) is one of the most important cereals in Ethiopia. It is also the most dominant among the tetraploid wheat species in the country. It has been under cultivation since ancient times. The country is recognized as the secondary center of genetic diversity for tetraploid wheats.

It is only recently that durum wheat landraces have been systematically studied for their effective utilization in the Ethiopian Durum Wheat Improvement Program. Germplasm collection from different durum growing regions, characterization for morphological traits and yield testing trials as well as development of composites has been under way since 1984.

Morphological diversity studies on materials collected from various growing regions have shown polymorphism for most studied traits. This variability is being utilized in the enhancement of the durum wheat landraces. With the growing population and dwindling agricultural resources in the country, improving the productivity of landrace, through evaluation and selections is vital.

Elite farmers' varieties (composites) were developed by selecting and bulking together three or more agrotypes with high yield potential as well as other various characters such as glume color, seed color that are crucial for farmers' preference. It was possible to identify high yielding composites that exceeded grain yield of the original landrace materials from the farmers' fields by 20 to 25%. In on-farm evaluation in terms of grain yield, straw yields as well as preferences and seed multiplication, the contribution of the farmers was significant.

Genetic diversity of the ICRISAT sorghum landrace collection—Management of the genetic resources

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The large number of sorghum (*Sorghum bicolor* L. Moench) landraces maintained at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) represents a challenge for utilization and conservation of this *ex situ* germplasm collection. A study of the phenotypic diversity in the collection found a wide geographical representation of the sorghum landraces and a large global morpho-agronomic diversity. This descriptive analysis of the collection will provide a key to enhance the use of these sorghum genetic resources. Different sampling strategies, either random or nonrandom were tested to obtain subsets of reduced size (core collections).

A first random sampling was applied on the collection stratified for photo period reaction (Logarithmic strategy: L). A second sampling took into account the morpho-agronomic diversity (Principal Component Score strategy: PCS). The third subset was based upon classification, geographical distribution, and uses of sorghum (Taxonomic strategy: T). These three subsets did not differ as far as the overall phenotypic diversity is concerned (Shannon Indices = 0.85, 0.85, 0.82, 0.83, for the entire landrace collection, the subsets PCS, L and T, respectively). However, the three subsets differed for various traits; the PCS subset looked representative of the total collection, the L subset differed for traits related to photoperiod reaction and the T subset showed a different distribution for several traits that were related to the morpho-agronomic characters and uses selected by farmers. Genetic diversity retained by each subset was assessed using the polymorphism at 15 SSR loci. The average allelic richness was equivalent for all subsets (16.1, 16.3 and 15.4 alleles per locus for PCS, L and T, respectively) as well as the average genetic diversity (0.81, 0.77 and 0.80). Generally, all the sampling strategies were effective to establish a core collection. The use of core collection could enhance the value of *ex situ* collection for participatory crop improvement and genetic resources conservation.

Opaque-2 gene for improving and conserving maize landraces

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Since 1969, this author planted many different native maize landraces of Oaxaca improved in their protein quality (i.e., high in lysine and tryptophan) by incorporation of the recessive opaque-2 gene derived initially from seed provided by Dr. J.H. Lonnquist of the International Maize and Wheat Improvement Center (CIMMYT).

In seeking improvement of the nutritional quality of local landraces for home consumption, opaque phenotypes have always been selected for the ease of their visual identification and reproduction by native small holders with limited resources. Analyses of these materials (with the opaque-2 gene) in the CIMMYT laboratories have demonstrated that protein quality is invariably improved. In addition, protein quantity, insect resistance, and yield also are often improved when compared to the original native parent landraces. In contrast with major opaque-2 programs, that promote normal-appearing hard endosperm maize hybrids to be monitored only by laboratory analyses for commercial production and use, our program promotes the improvement and conservation of local adapted maize landraces by incorporation

of the opaque-2 gene of visually floury endosperm requiring no costly laboratory analyses.

The principal focus of this project is improvement of the protein quality, productivity of the land and improvement of the diet and well being of the local people. In addition to the above, the methodology for incorporation of the single recessive opaque-2 gene into any variety of maize is considered an excellent tool for introducing practical genetics into the curriculum of education programs for the entire community to better comprehend, participate in, and support the improvement and conservation of crop genetic diversity.

Agrobiodiversity in the *aynokas* of quinoa (*Chenopodium quinoa* Willd.)

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Aynokas are communal fields, which represent a traditional production system and organization of the fields in the Andean mountains, with the purpose of securing food production in rural communities. The system is based on an appropriate handling by the farmers of the available genetic resources, alleviating the adverse effects of variability in soil, climate and topography, and utilizing a range of sowing dates. The plots are distributed and managed within the community, each crop organized in large fields.

Quinoa (*Chenopodium quinoa* Willd.) is one of the most important crops of the Andean highlands, having an exceptional nutritional quality and resistance to drought, frost and other adverse factors. Quinoa is therefore an important part of the *aynokas* of this region. Within the quinoa *aynoka* is found a high diversity in characters such as inflorescence shape and color, earliness, resistance to adverse factors (drought, frost, flooding, hail, salinity, pests and diseases) and saponin content.

The diversity of the crops in the fields of the highlands, expressed by genetic and phenotypic variation of agronomic characteristics, is very important, because it makes it possible to grow a food crop like quinoa under harsh climatic conditions, and with few inputs. This is utilized in the *aynoka* system from marginal highland regions with fragile ecosystems, such as the Bolivian and Peruvian altiplano, enabling the farmers to produce food of sufficient quantity and quality, mainly for autoconsumption. During the last years the extension of *aynokas* has decreased, as a consequence of the introduction of new technology and new varieties. However, the widespread and continued use of the *aynokas* of quinoa will secure a stable food production and conservation of the genetic diversity for the Andean population living under extremely difficult environmental conditions.

Plant genetic resources for sustainable agriculture

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Sustainable agriculture, according to TAC (1989), should satisfy changing human needs while maintaining natural resource base and avoiding environmental degradation. Since human needs are modulated by social, cultural and economic conditions, sustainable agriculture (SA) has a strong dependence on socio-cultural aspects. Regardless of societal preferences and economic needs, sustainable agriculture (SA) entails management systems suitable for physical and ecological conditions of the cropland, as well as appropriate genetic diversity of target species.

Although an impressive number of plant genetic resources (PGR) are preserved *ex situ,* the potential value of PGR of individual crops for SA is nearly unknown. Since PGR cannot be precisely identified unless physical and ecological conditions for sustainable agriculture are known, the best one could do is to evaluate the available PGR of target species under a wide range of conditions, emphasizing adaptedness, rather than adaptability of individual accessions. This may be a formidable task. An alternative approach would be to utilize nonrandom zygotic associations. This may be facilitated by (a) identifying geographic regions that have higher frequencies of useful genes or gene clusters in *ex situ* preserved PGR, and (b) propagating PGR from these regions under conditions that promote relatively high frequencies of nonrandom zygotic associations.

In this review, I will provide evidence for useful multilocus associations in chickpea and durum wheat and demonstrate that location-specific nonrandom associations can be efficiently determined using the data mining technology of information sciences. I will argue that participatory conservation of crop genetic diversity under low-input conditions could provide optimal conditions for developing useful multilocus associations, while maintaining genetic diversity both within and between crop populations.

Farmer varieties and genetic distinctiveness

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The International Plant Genetic Resources Institute (IPGRI) project on strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm has an explicit investigative component concerned with the contribution that on farmer management of local crop varieties can make to the conservation of crop diversity. Agromorphological and other features are used by farmers to distinguish and often name crop varieties. These features are also commonly the basis for farmers' selection of planting seeds. The way in which farmers manage their crop varieties and the diversity these varieties contain is central to the development of effective on-farm conservation strategies. Farming communities were selected in areas of high intra-specific crop diversity of major crops in 14 agroecological sites in Burkina Faso, Mexico, Morocco, Nepal and Vietnam. Lists, together

with criteria that farmers used to describe, recognize and name their varieties, were complied using participatory methods and direct observation in fields and granaries. Field trials and laboratory analysis are being conducted to evaluate the genetic distinctiveness of these varieties. The number of named varieties differs significantly between countries and sites. This is discussed in terms of differences in human cultures, crop breeding systems (inbreeding, out-crossing, clonal), and diversity of agro-ecosystems.

The role of maize production in the economy of a village from Chalco Valley, Mexico

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The main objective of the research is to analyze the impact that different policies applied to maize had on production and on households' incomes in a village near Mexico City. This rural community is an important maize producer. Its production is based upon local seed, which has higher productive potential than improved seeds. However, the main income source of the households comes from their involvement in the labor market in non-agricultural activities in nearby cities, mainly Mexico City. Although maize production is not profitable, farmers produce it for own consumption, partially because the salaries that the household members get outside the village are low and sometimes temporary. We applied a survey to a representative sample of households in order to obtain data on the socioeconomic structure of the village. With this data we have built a Social Accounting Matrix (SAM), and through this SAM, we have done multiplier impact analyses to estimate the effect of the different agricultural policies on the village economy, as well as on their households' activities and incomes. Our results indicate that the maize production could be profitable if governmental support programs for the farmers were available. One of our results indicates that the injection of exogenous resources to local maize production increases the incomes of the households. Notwithstanding that the injection does not improve significantly the Gross Village Product, it has redistributive effects between the village's households.

Understanding the impact of farmer's markets on the exchange and conservation of local papas varieties in Cajamarca, Peru

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The potato (*Solanum* spp.) plays an important cultural and subsistence role in rural communities throughout Peru. Potato germplasm diversity is threatened by the spread of improved varieties, farmers' inability to obtain native seed, and declining production knowledge. This threat is evident in the northern province of Cajamarca, where regional markets and erosion of traditional knowledge have impacted the conservation of native varieties. This paper examines the factors influencing the conservation of native potato varieties in three districts within Cajamarca, and discusses the role of regional seed fairs as a tool to reinforce the local systems for the exchange of knowledge and crop germplasm.

Farmer gardens: Best living gene banks

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The consciousness today about genetics resources and their importance to human kind is at an all-time high. Discussion has focussed especially on the loss of indigenous varieties (or "genetic erosion") and the control of germplasm by vested groups or commercial interests. Varieties are being lost as they cease to be cultivated. There is an outcry to search out and retrieve these vanishing varieties, if not for any other reason than for preservation, in a similar way in which the curator in a museum preserves heirloom cutlery. Indigenous varieties are sources of useful genes concerning special qualities such as local preferences, resistance to disease or drought.

It seems clear that conservation will not result from workshops and conferences on the topic of genetic erosion even as we admit these are important at certain stages of the campaign. Nor will it result only from storing seeds national or international germplasm banks, because of the need for these plants to continue their process of evolution and adaptation.

Historically, the best conservers of seeds have been small farmers and backyard gardeners, but programs to conserve seeds at their level are sadly lacking. Meanwhile, every day, the seed heritage slowly but steadily diminishes. The concept of a farmer/gardener curator is important because the seeds used by the majority of today's farmers in developing countries (with 80% of the world's population) have been handed down by generation of farmers. When planted out every year, these varieties continue to evolve and adapt to the changing environment. These same seeds, stored in conventional low-temperature seed storage facilities, are dormant and do not evolve further their characteristics remaining unchanged. Seed conservation is everybody's concern and not an activity limited to genetics and breeders.

This paper discusses the concept of a farmer/gardener curator, local seed saving techniques and exchange.

Participatory varietal selection and biodiversity in rice in the Indian Punjab

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Rice variety Pusa 44 occupies more than 50% of the rice area in Patiala district, Punjab even though the Punjab Agricultural University (PAU) does not recommend it because of its high susceptibility to bacterial leaf blight (BLB). However, farmers grow it because it is high yielding and does not lodge. The predominance of Pusa 44 has reduced on-farm varietal diversity. Its late maturity requires it to be transplanted very early in the season, as early as the first week of May, when temperatures are very high. This greatly increases the demand for irrigation water and contributes to a further lowering of the water table, a serious problem in parts of the Punjab. Varieties recommended by the PAU have not provided a suitable replacement for Pusa 44, so participatory varietal selection (PVS) was used to provide alternatives to Pusa 44. In 1999, 12 varieties were provided to 497 farmers in 11 villages for testing. These varieties were chosen irrespective of their release in the Punjab since formal multi-location trials often do not determine the precise recommendation domains of varieties.

Three varieties, IR64, IR36 and PR114, performed better than Pusa 44 in farmers' fields. Farmers transplanted IR64 along with Pusa 44 on varying dates between 1 May to 15 July 1999. IR64 yielded 5% more than Pusa 44 in 43 trials, and in trials that were transplanted between 21 to 30 June, it yielded 12% more. Hence, IR64 can be transplanted 3 to 4 weeks later than Pusa 44 with no yield loss. These differences arising from changes in planting date were not revealed in formal trials.

IR64 has several other benefits: it is resistant to BLB, has better grain quality than Pusa 44, and it can reduce the use of irrigation water by 20 to 30%. It also allows time between the wheat and rice crops to grow a crop for green manuring or to grow a short-duration pulse crop to improve soil health and fertility. In 2000, trials are being conducted to test these new practices.

Impact of deforestation on diversity of wild and semi-wild edible fruit tree species in southern Malawi

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Impact of deforestation on diversity of wild and semi-wild edible fruit tree species in Mulanje and Mangochi districts of Southern Malawi was studied. In each district two sites designated as 'forested' and 'deforested' were selected where the former were government protected forest reserves, while the later were communal land covering grazing lands, graveyards and open areas of crop fields.

Data was collected on historical background of vegetation of the areas, changes on the vegetation, species of wild and semi-wild edible fruit trees, ecology, availability, nutritional and economic importance through group interviews with local communities and by conducting an inventory of the fruit tree species by sampling transects across each site. Analysis and T-test of results showed that forested sites had significantly higher Species Richness (S) and abundance (N) of wild and semi-wild fruit trees than deforested sites. On the other hand deforested sites had significantly higher Shannon Indices of diversity (H') and Evenness (E) than forested sites. Mulanje sites had generally higher S, H', and E than Mangochi sites. *U. kirkiana* was the most abundant species in forested sites of both districts, while *Anona senegalensis, Azanza garkeana* and *Zizyphus mauritiana* were the commonest in deforested sites. Despite the fruits' nutritional and economical importance no efforts have been made by the local communities to domesticate them. Lack of proper propagation techniques was a major problem to domestication of these fruit tree species. Fruit species like *Tamarindus indica* which were once common are now rare due to deforestation.

Effect of photoperiod, night temperature, and sucrose level on *in vitro* growth of *Plectranthus esculentus* shoots

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Plectranthus esculentus, locally known as African potato, is an important indigenous tuber crop in central and southern Africa. However in many parts it is semi-domesticated and its production is limited by unavailability of planting materials. Use of stem cuttings through tissue culture techniques has been recommended as a way of rapidly increasing its planting materials. Therefore effect of photoperiod, night temperature and sucrose level on *in vitro* growth of *Plectranthus esculentus* nodal cuttings was studied to determine optimum in vitro conditions for rapid multiplication. After 28 days of incubation, continuous dark conditions resulted in pale and etiolated shoots while 8, 12, and 16 hours photoperiod did not significantly differ in their effect on number of internodes, plant height and number of branches. High night temperature (18°C) promoted internode and shoot elongation more than low night temperature (8°C) while short (8 hours) and long (18 hours) photoperiod did not significantly differ in their effect under interaction with the two temperatures. Variation in sucrose levels (3%, 6%, and 9%) in the medium did not significantly affect growth of the shoots across the photo period range hence high levels were not beneficial. For purposes of rapid multiplication through nodal cuttings of this tuber crop, photo period range of 8 to 16 hours and incubation temperatures above 18°C would be

preferred. Higher levels than 3% of sucrose appear to be of no added benefit. None of the treatments induced microtuber formation even after extending the incubation period to 60 days.

Re-evaluation of the knowledge and use of greens in the Sierra Norte de Puebla of Puebla, Mexico and its relationship with *in situ* conservation

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In the last years, greens (quelites) have become an issue of great interest, concerning the programs of health and food security. Regarding the MILPA project we pay special attention to these plants, because they are potential crops or wild relatives of the some crops studied in our own project.

The human impact through agricultural practices allows a symbiosis between cultures and greens, enhancing them to a coevolution within the milpa (corn field). The careful and slow selection was the way for the initial domestication. The results obtained in the study about greens in the Sierra Norte of Puebla show that they constitute an important resource due to the variety of plants used for this purpose (i.e., more than 70 species), as well as for its contribution to the nutrition of the people in the Sierra Norte. There are clear evidences that in the present time, the youngsters as well as the children population are not interested in this resource and therefore, many greens are used occasionally. Based on these statements, there is a great need to let the people know about the programs of investigation and *in situ* conservation.

For that purpose, we started with an exhibition in the community in which we show the cultural and biological potential of the greens. Besides that, we give some orientation to the people about basic nutritional issues (i.e. types of food and diseases caused by lack of nutrients). This exhibition has been visited by around 900 people in three different communities. A careful registration of the participants of this event was performed. Questionnaires were also applied, in order to evaluate the impact in the communities. The greens present in several agroecosystems in the milpas (corn fields) are the easiest way to show the peasants what the MILPA project is all about and, at the same time, that they realize the value of these plants as a resource to be preserved. In the same way, they will value the preservation of the agroecosystems from which the greens are obtained. The inclusion of the greens in programs related with the conservation of plant genetic resources gives the idea of the cultural and biological atmosphere of how the weeds in the milpa (corn field) are supposed to be managed. Some of these weeds are species that may become new crops for the communities in which we perform the multidisciplinary investigations of our project.

Possible role of locally adapted populations (landraces) in organic farming in Hungary

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The expected life span of Hungarian citizens has gradually decreased during the last two decades and is actually around 65 years for males and 74 years for females (Hungarian Statistical Monitor, 1996). Dietary tradition and customs probably contribute, among other factors, to the high incidence of cardio-vascular diseases, the most frequent cause of middle-age mortality in Hungary. Preliminary studies have indicated that some biologically active compounds like trace elements, other minerals, essential amino and fatty acids, antioxidants, vitamins and alkaloids occur in lower concentrations in high yielding cultivars compared with some traditional landraces and underutilized crops preserved in gene banks or maintained on farm.

The disease preventive role of "functional foods" has been highlighted by food chemists and most of the scientists studying the health status of human populations (EURO FOOD X, 1999). Equilibrium populations (landraces or populations selected on farm) adapted to local environmental conditions assumed to suit to the requirements of low input organic farming systems. They can also be selected to produce raw material for functional foodstuffs with high nutritional value and lower level of antinutritive and poisonous substances. Utilization of gene bank accessions for such purpose can provide an alternative way of dynamic maintenance of genetic resources and contribute to the development of sustainable agricultural models. Ongoing research at the Institute for Agrobotany on bean (*Phaseolus vulgaris*) landraces collected from 15 villages of three different ecological regions has revealed differences directly related to qualitative traits (general chemical composition, level of anti nutritive substances, sensorial characters, etc.). Lettuce (*Lactuca sativa*) landraces were studied to assess the nitrate accumulation under different growing conditions, including winter enforced growing experiments. The 118 landraces studied performed a wide range of variation for all the characters evaluated. The mean nitrate content was lower and the coefficient of variation for nitrate content was almost twice as much (32.5%) for landraces than the same for modern cultivars.

Flavonoids, a group of colored substances in plants, are essential in the absorption and metabolism of vitamin C, and also protect blood vessels and reduce platelet aggregation (acting as natural blood thinners). The buckwheat (*Fagopyrum esculentum*) accessions studied showed a wide range of within and between population variation in rutin content (3.4 to 8.5% in leaves and young shoots) and in other flavonoids like quercetin (0.001 to 0.059%) and quercitrin (0.001 to 0.384). Similar variation was found also in dehulled seeds. Preliminary results obtained indicate that genetic resources collections are suitable and promising sources of germplasm for organic farming and for the improvement of the nutritive value of foodstuffs.

Wild bean populations as source of genes to improve the yield of cultivated *Phaseolus vulgaris*—Preliminary results

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Evaluation of genetic resources is of paramount importance in the process of developing new, improved cultivars. The purpose of this study is to determine whether wild beans can serve as a source of genes to improve yield and yield components of cultivated common bean. Recombinant Inbred Line (RIL) and Inbred Backcross Line (IBL) populations were developed from crosses between an improved cultivar and two wild Mexican beans. These four populations are currently in their second year of evaluation. The results obtained during last year's evaluation for the RIL are presented.

Two populations consisting of 196 RILs each, were evaluated during the summer of 1999 at the El Batan-Texcoco experimental station. The traits evaluated were yield and yield components. Histograms for yield for each RIL population as well as graphs for the relationship between yield and yield components will be presented. These preliminary results show some lines with seemingly favorable combinations from the parental lines. The field evaluations for a second year, as well as the molecular analysis of such lines are currently being carried out to determine whether or not the wild accessions are donating favorable genes to the cultivated genotype, as well as to determine the linkage relationships of these potential genes to genes coding for wild, deleterious traits.

Genetic variation and response to combined selection in Mexican squash landraces (*Cucurbita pepo* L. and *C. agryrosperma* Huber) within the milpa cropping system

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Two different breeding strategies have been conducted to improve landrace varieties of two species of squash *(Cucurbita argyrosperma* and *C. pepo)* grown by farmers in central Mexico. The goal is to achieve positive response to selection of traits of interest while at the same time maintaining high within-population diversity, a desirable characteristic in traditionally managed cropping systems. One approach involves on-farm selection of local landraces conducted in association with local farmer-cooperators. One such project targeted a population of *C. argyrosperma* var. *stenosperma* in Achichipico, Morelos. A second approach entails evaluation and selection of desirable traits within germplasm pools of landraces representing regions of interest. A focus of this type of breeding strategy has been an experiment station-grown, synthetic population of *C. pepo* derived from 120 families of landrace populations collected from the Chalco area of the state of Mexico and the Sierra Norte de Puebla. In both projects, maternal half-sib, combined family selection was applied. Maize-squash intercropping grown in randomized complete design was used. In general the genetic diversity was found to be high in all traits evaluated but the selection decreased. For both populations the total genetic variance was determined by additive effects of the genes. In *C. argyrosperma* the heritability ranged between 6 to 90 % in the for both years, and flesh thickness increased 0.14 cm. In *C. pepo* the dominance variance was negative and highly significant. The heritability ranged between 29 to 95% for both years. The variation in mature fruit quality made important advances for *C. pepo*. In the first year undesirable fruit flesh color (pale) and flavor (insipid) of 50 % and 30 %, respectively were obtained, while in the second year desirable flesh color (orange) and flavor (sweet to very sweet) increased to 61 to 63%.

Management of genetic diversity and crop improvement of squash within a traditional maize-based cropping system

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Four species of squash *(Cucurbita* spp.) are grown widely throughout Mexico, mainly for consumption of seeds and immature or mature fruit. Squash is principally grown as an intercrop in a maize *(Zea mays)*-based, rainfed cropping system known as the "milpa" (literally, "place of maize") for both home consumption and local or distant markets. In Mexico, most production continues to occur with locally adapted landraces rather than improved varieties. Despite its cultural significance and widespread production, until recently there were virtually no government breeding programs for squash. In 1995, a six year research and training project entitled "Conservation of Genetic Diversity and Improvement of Crop Production in Mexico: A Farmer-based

Approach" was initiated with funding from the McKnight Foundation's $12 million Collaborative Crop Research Program. The project jointly addresses the human cultural and economic processes and the biological and evolutionary factors that affect productivity, conservation, and improvement of native crop genetic diversity. The three core objectives are concerned with farmer management of crop germplasm; crop biodiversity and gene flow characterization; and development of on-farm participatory breeding methodology. The MILPA Project focuses on the genetic resource base of three crop commodities—maize, squash, and beans *(Phaseolus vulgaris* L.)—and associated edible weeds, known locally as "quelites", which are agricultural or ruderal weeds harvested typically as leafy vegetables. Faculty staff, and students of 5 Mexican and 4 U.S. universities and researchers from the Mexican national agricultural ministry (INIFAP) and an international center (CIMMYT) are collaborating with farmers and communities located in mid to high elevation regions of 4 states in central Mexico. Research and training activities conducted by the Squash Group—one of the five subgroups of the MILPA Project and co-led by Drs. Laura C. Merrick of ISU and Clemente Villanueva of UACH—are described.

Stratified visual mass selection in maize landraces from the Chalco-Amecameca region

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This work is part of the "Milpa Project" and is aimed to prove the effectiveness of stratified visual mass selection (SVMS) as a method of participatory plant breeding of maize landraces in the Chalco-Amecameca Region.

Four cycles of SVMS on six maize landraces, with farmer participation, was carried out in the Chalco-Amecameca Region in 1995–1998. The original landraces, the four cycles of SVMS, four commercial checks, and four outstanding landraces were agronomically evaluated in 1999. Field evaluation was done in Poxtla, Ayapango Municipality; Juchitepec, Juchitepec Municipality; Tlapala, Chalco Municipality; and Tecamac, Tecamac Municipality, all of them in the State of Mexico; the first three locations under rainfall conditions and in Tecamac under irrigation.

The average ear yield per hectare of the six populations, in the four locations was increased by 2.9% in the first cycle, 4.7 % in the second cycle, 13% in the third cycle and 14.2% in the fourth cycle of SVMS. Ear height reduced by 8 % in the first cycle, 9% in the second, 9 % in the third and 11% in the fourth. Number of days to silking and kernel size were almost the same for all the cycles of SVMS and the original landraces. The commercial maize showed disadvantages such as more days to silking, shorter ear length and smaller kernel size compared with the landraces and their selected versions. With SVMS, favorable gains for grain yield and reduction in plant height were observed, and almost no modification of earliness and kernel size.

Chalco and Sierra Norte: Contrasting experiences in maize particpatory plant breeding in the "Milpa" Project

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The**"**Milpa" Project is in its sixth year. In this paper we present some experiences of the Maize Team in order to contribute to plane further projects. The"Milpa" Project is concentrated mainly in two contrasting regions: Chalco-Amecameca and Sierra Norte de Puebla. Chalco-Amecameca is a highland (2240 to 2700 m. above sea level), more or less flat, with deep soils, "mestiza" culture, 40 minutes by car from Mexico City. The Sierra Norte is a mountainous region (from 400 to 2700 m above sea level). Here there are 4 traditional ethnic groups; it is 5 to 7 hours from Mexico City by car.

Problems common to the two regions. Genetic resources are important limiting factors but not the only ones in maize production. There are other serious problems: low price of grain and tendency to fall even lower as a result of NAFTA, and also the competition of maize production with other crops and activities. There are methodological problems for assessment different products obtained from maize field. It is usual for farmers to receive subsidies from programs, but this is not recommended for PPB projects. For wide adoption of project-proposed innovations, it is necessary to work with farmers' organizations and strengthen them.

Additional problems in the Sierra Norte**.** Small farm plots with areas within of each maize variety. Tremendous heterogeneity in maize fields as a result of microrelief, rocks and intercropping of many plants. Varieties and practices are different among nearby sites as a result of differences in altitude and climate. In the project there is only one full time researcher and it is difficult for the others researchers to be in the Sierra Norte frequently since it is far from Valley of Mexico, where we live and work. The result is that the Maize Team progress in the Sierra Norte is slower than in the Chalco region.

How significant are biodiversity fairs for promoting participatory plant improvement?

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The spontaneousness and creativity of the remarkable maize farmers from the Agroecological lighthouses of "Gilberto Leon", "Jorge Dimitrov", in San Anatonio de los Baños, and "28 de septiembre", in Batabano, Havana provinces were

presented at the two-day Biodiversity Fair organized in the National Institute of Agricultural Sciences (INCA) in Havana. It demonstrated how appropriate farmers' best genotype selection was under sustainable conditions. Several varieties collected in "La Palma", Piner del Rio province, and "Catalina de Guines", Havana province were much better in yields when evaluated under low-input conditions, than the supposedly high-yielding commercial varieties derived with another technology. Farmers discussed different criteria with the research staff of INCA at the workshop organized during the Fair.

Innovations, institutions, incentives, an policy interventions for participatory crop improvement and conservation : Experience of SRISTI with innovative farmer breeders

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The increasing genetic uniformity in high yielding varieties has made agriculture extremely vulnerable. *Ex situ* gene banks have not only failed in stemming the erosion of local germplasm but also failed to meet the needs of local farmers in developing countries from whom the germplasm as originally collected. The burden of conserving biological diversity predominantly rests on the shoulders of small farmers who generally inhabit high-risk environments. However, the documentation used by gene banks excludes information about socio-cultural practices and preferences of farmers associated with their local varieties. Recently, there is a growing realization among scientists of the necessity to involve farmers in various processes of plant breeding. In spite of the best intentions however, participation of farmers has remained limited to either varietal screening or on-farm testing. Though evolution is a natural process, sometimes the goals of crop improvement conflict with the goals of *in situ* conservation of local landraces in cultivated crops. The paper will illustrate the examples of innovative individuals and communities who have met the challenge of making the trade-off between crop improvement and conservation of landraces. It examines social and cultural institutions that have emerged for *in situ* conservation as well as improvement of landraces. The role of women's indigenous knowledge systems will be examined in the context of crop improvement and germplasm conservation.

The paper builds on rich experience of the Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) in encouraging innovative individual farmer breeders to select, breed, multiply, disseminate and conserve their own local land races through on-going experimentation. The role of scientists in capacity building of farmer breeders as well value addition to local varieties developed by farmers would be discussed with empirical examples. Various models employed by SRISTI for providing material and non-material incentives to farmer breeders will be discussed at length. The final part of the paper deals with the kind of policy environment required for encouraging the partnership between public as well as private research institutions and economically poor but knowledge rich farming communities. It would also examine the impact of various international agreements and national policies on farmers' experimentation and their rights on local germplasm.

Genetic improvement of 12 corn (maize) landraces by recurrent selection in the coffee-growing zone of Huatusco, Mexico

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The project consisted of improving 12 varieties of landraces of maize: Tuxpeño, Olotillo, Bolita, and Coscomatepec, thoroughly diffused in the coffee region of Huatusco-Tlaltetela in the state of Veracruz, Mexico. The technique used was that of Recurrent Selection (Márquez, 1990; Márquez, 1998) according to which a variety of open pollination (recurrent) upon crossing with an improved variety (donor) a hybrid with a high potential for heterosis is obtained. The donors used were five genotypes, which were selected for eliminating the characteristics of the landraces that the peasants determined as not desirable, mainly: low height, and quality of ear. The material was collected during 1993 and after four seasons (F4), the seeds were given back to the peasants in 1997 for sowing, thus continuing the process of improvement through the mass selection. During all selection/improvement processes training courses using graphic materials with the basic information were also carried out. The results indicate that the genetic composition of the hybrid is of 75% landrace and 25% improved variety. This allows conservation of genetic variation of the local material while adding a minimum of exotic material.

Participatory improvement of maize production in indigenous villages of the Sierra Norte de Puebla, Mexico

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The objective of this project is to improve maize production of poor small indigenous farmers in a region of the Sierra Norte of Puebla. Maize is the most important component of

these farmers' diet, producing it for own-consumption, but in insufficient quantities to cover their needs. This situation translates into an acute problem of food insecurity due to the farmers' low incomes. Therefore, improving maize production would contribute to enhance food security and farmer's and their families' welfare.

Through the use of participatory diagnostic methods, maize cultivators in one community showed that while they regarded their local varieties as good, they also admitted that they had problems—mainly high stature—and therefore prone to lodging. Consequently, they wanted to test new maize varieties. Farmers and scientists agreed to jointly evaluate 22 maize varieties, both local (14) and external (8). Through or research we found that many local maize varieties are unknown to most farmers, many of them with desirable characteristics. Such evaluation included a demonstration in which farmers from the community and of five surrounding ones participated. During these displays they became acquainted with the germplasm, and gained knowledge of varieties with desirable traits. While an improved external variety had the best agronomic performance and the highest yield, farmers demanded seeds from one of the outstanding local varieties, even though they could obtain other variety free through a government program and the local one had to be purchased. We are currently involved in scaling up this effort to the micro-region. This we do through our work with a regional farmers' cooperative. The results that we obtained suggest that disfavored farmers are constrained in their knowledge and access to their local germplasm, and that providing those may be important to improve regional productivity and, hence, food security.

Some experiences of the participatory plant breeding on soybean crop in Cuba

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Several agricultural research reports in Cuba have stated the existence of edaphic climatic conditions suitable for growing soybean crop in Cuba. However, its production is still low and investigations are underway to improve production using advanced technology. Plant protein demands are an every day feature in Cuba but the present economic crisis does not allow our country to import enough amounts of it. Therefore, since the very beginning of this 1990s, the National Institute of Agricultural Sciences (INCA) has been searching for appropriate varieties and technologies for use by small holders to increase production under low input and biotic-abiotic stress conditions. This study comprises various aspects such as: plant breeding development, the impact of two field days with private producers in Spring 1997 and 1998, as well as farmers' results of using a group of varieties to implement *in situ* seed preservation.

The dynamics of tuber seed management by subsistence farmers in the Andes of Peru and Bolivia—Environmental and cultural correlates

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We report on three studies of minor tuber crops (other than the potato) that shed light on farmers' practices that promote the maintenance of landrace diversity. More specifically, we present a comparative analysis of farmers' practices in three areas that share in common the cultivation of minor tubers and that are located over an ancient tuber seed exchange route, but differ ethnically, in their culinary traditions, and have varying degrees of connection to the market. We focus on oca (*Oxalis tuberosa*), the most important tuber crop after potato in its contribution to the Andean diet and to on-farm landrace diversity. Since a key factor contributing to the continued cultivation of oca is the availability and access to healthy/vigorous tuber seed, we have documented seed management practices in detail. The tuber collections of known farmer families at sites in Cuzco and Yunguyo in Peru, and Candelaria in Bolivia were monitored over 12 cropping seasons (combining the three locations). We surveyed the composition and use of landraces for each micro-region, documented the criteria used by farmers to select tuber seeds for planting, the sources of tuber seed for each planting, and the frequency with which new/fresh tuber seeds were incorporated into the next tuber seed lot. We present estimated rates of landrace loss and rates of landrace adoption for the three studies. These findings are discussed in relation to climate, pests, landrace preferences, culinary traditions, and connections to the market.

Genetic improvement initiatives leading to intensive conservation including genetic integrity in little millet in India

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Minor millets are small seeded cereals, rich in micronutrients like calcium, iron, and zinc and grown in poor edaphic and climatic conditions in Kolli hills (Tamil Nadu) situated in south India. In most of the hilly regions cropping systems have a millet species as a dominant component. Such systems have been preferred by tribal farmers as they provided sustainable benefits. But in the last two decades, active introduction of high yielding varieties of food and commercial crops have changed the focus to commercial production relegating cultivation of millets to an obscure background. This has led to genetic erosion of millet diversity

Little millet (*Panicum sumatrense*) is one species of small millets whose landraces, preferred by farmers, is being

rapidly displaced by commercial introduction of crops like cassava. M.S. Swaminathan Research Foundation working with millet farmers is concerned to bring back cultivation of small millets and also to revitalize their conservation of local landraces and cultivars. A participatory Rural Appraisal in this context, with site farmers revealed their abiding interest in small millets, but getting eroded by the poor productivity of landraces under traditional cultivation. It was found ideal in such a backdrop to introduce scientific steps to optimize their cultivation practices under site-specific constraints. Under a program of Swiss Development Corporation, optimization of cultivation practices was taken up under a participatory plant Breeding (PPB) activity. A two-season operation of these initiatives has clearly shown the following:

- Long discontinuation of small millet cultivation has not yet destroyed the inherent genetic diversity
- The genetic integrity of short and long duration landraces is still maintained
- Even out of seven prevalent landraces, sufficient genetic diversity existed giving four distinctly different genetic groups
- Introduction of formal practices into farmer method of cultivation has improved the productivity up to 200% at no extra cost.

The processes leading to such a development will be highlighted. It would be emphasized that the ground realities of activity sites and target farmers should be the base to set site- and farmer-consonant PPB initiatives not only for genetic enhancement but also for conservation of genetically integral of landraces of millets in India.

Biological results, energy efficiency, and financial profitability of collaborative plant breeding in Cuba

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Major changes in the economy of Cuba since 1989 have led to reduced inputs in agricultural production. This has resulted in changes of some concepts in plant breeding. This turn has led to a search for new, more appropriate methods of plant breeding for cross-pollinated crops as squash and maize, including consideration of collaborative plant breeding (CPB). The paper reports the contribution of farmers and researchers in collaborative plant breeding under low input conditions. The farmers offered friendly the pumpkin and maize landraces collected by scientific mission. The materials collected showed a wide variability under low-input conditions capable to response in different area characterized by low input agriculture. Farmers offered a real scenario and capability for selecting genotypes under low conditions interacting biotic, abiotic stresses and socio-economic constraints as well as the possibility of obtaining advance in characters with complex inheritance such as yield. The plant selection scheme methodology developed by farmers demonstrated an open system to incorporate genes enriching the community gene pool maintaining the main characteristics of the variety and acceptable yield.

On the other hand plant breeders enhanced plant genetic flow between materials conserved *in situ* and *ex situ* in order to alleviate varieties deficit to low income condition. Plant breeders offered experimental advice, an estimation of plant genetic variability, and genetic advance of complex characters such as yield monitoring the variability in time and space. Besides they showed the economic advantages of selecting under low-input conditions incorporating new materials, promoting an ongoing recombination.

This paper describes why CPB might be a positive response, in terms of biological results, energy efficiency and farmers' financial profitability.

Genetic diversity and heterosis in crosses of native populations of maize from Chalqueño race

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In the high central valleys of Mexico (from 1900 to 2700 m above sea level) the main crop is maize, and 95% of the seed used is produced by farmers themselves from native populations.These populations belong mainly to Chalqueño and Conico races. Chalqueño is a very productive race. The genetic diversity within the Chalqueño race is very broad. The objective of this research was to identify the best intervarietal crosses and to identify the relationships of heterosis and genetic divergence within this race. Thirty-nine oustanding native populations of Chalqueño from twelve geography origins or regional genetics groups (RGG) and ten races closely related to Chalqueño, were crossed with three Chalqueño testers.

The 111 crosses obtained and the parents were evaluated in 1998 in two field environments. The grain yield of the best ten crosses was statistically equal to the best commercial check, and their heterosis was 25.3 to 52.7%, 38.2 to 85.2% and 15.6 to 34.1% with respect to the midparents (HMP), native populations (HNP) and testers (HT), respectively. The overall mean grain yield of crosses (4 493 kg/ha) was statistically equal to tests (4 713 kg/ha), but superior to native populations (3 735 kg/ha). Heterosis was associated with the genetic divergence. The r of Pearson (correlation coefficient) between HMP and geography distance (km) was of 0.79** and with a squared Mahalanobis distance of 0.75*. Oaxaca , races closely related to Chalqueño, Durango-Zacatecas, Michoacan and Hidalgo RGG showed the highest heterosis. The genetic divergence within the Chalqueño race was explained mainly as a response to different natural agronomical and cultural conditions of selection processes, and also introgression with other races. The additive variance resulted to be higher than dominance variance, indicating that there are good

possibilities for genetic breeding by selection and conservation *in situ* within the Chalqueño race.

Local faba bean germplasm enhancement through recurrent selection in Morocco

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A germplasm enhancement for improving yield was initiated in the local Moroccan populations of faba bean using a recurrent selection system. Initially a broad-based gene pool (MFGP) was developed by polycrossing 40 'core' local accessions that were chosen from 5 clusters generated by multivariate analyses of identification, characterization and evaluation data sets. Three selection cycles were completed through a multitrait selection based on three yield components (number of pods, number of seed per pods, and seed weight). Each cycle consisted of choosing individual plants based on half sib progeny test and polycrossing the selected progenies the following season. The three resulting subpopulations (MFGP-I1, MFGP-I2, MFGP-I3) and the parental MFGP population were evaluated in 1998 and 1999 to assess the response to selection.

The differences were significant between the 3 subpopulations and the parental gene pool. The plant yield was significantly improved achieving a total increase of 148 %, indicating that recurrent selection was effective in changing the population performance and saving the genetic variability. The responses in yield components were consistent with the yield improvement. The greatest increase was observed in the number of pods per plant (145 %). Utilization of these subpopulations is discussed. They can be released directly as varieties in the short term. They can serve as improved germplasm sources to derive elite lines which might be evaluated for reactions to important biotic (*Orobanche*, *Botrytis*) and abiotic (drought) stresses.

Genetic resources and conservation of spices by small farmers

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Black pepper (*Piper nigrum* L.), ginger (*Zingiber officinal*e Rosc.), and turmeric (*Curcuma loga* L.) are important spices of India. India is the major producer and exporter of these commodities in the world. The center of origin as well as the center of domestication of these crops is more or less the same unlike in other cultivated plants. There are about 100 land races of black pepper, 60 cultivars (farmer's varieties) of ginger and turmeric each available in the country. These are mainly maintained by small and marginal farmers including farm women. All the three above spices are propagated vegetatively. Farmers grow the clones separately. In case of black pepper runner shoots are used for propagation. Black pepper clones are identified by leaf shape, spike nature, shoot tip color, vine feature etc. Generally the clones are named in vernacular indicating a specific feature of the vine, for example 'Vella namban' ('Vella' = white; 'Namban' = shoot tip) or place of origin, e.g: 'Perambra munda' ('Perambra' = place in Kerala; 'Munda' = vine) or after a person who domesticated the vine, e.g., 'Thomman kodi' ('Thomman' = a person's name, 'kodi'= vine). Though ginger and turmeric clones are rather difficult to identify based on rhizome morphology, farmers prefer to maintain the purity of the clones. Rhizomes saved from the previous harvest forms the planting unit. Farm women are also involved in selecting the seed rhizome. Rhizomes are preserved under indigenous conditions. Leaves of plants like mango, *Glycosmis cochin chinensis*, etc. are used for preserving the rhizomes. Ginger and turmeric clones are also named in vernacular indicating the place of domestication or the place of origin. Vegetative propagation helps to maintain the purity of the germplasm.

Participatory improvement and conservation of crop genetic resources in agroforestry system in Indonesia

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Agroforestry has been practiced by Indonesian rural community since a long time. Various agroforestry systems can be found in Indonesia due to different biophysical conditions, influenced by existing diverse social and cultural aspects. Several stakeholders are involved in improvement and conservation of genetic resources, i.e. government, local communities, private sectors and NGOs. In a very traditional agroforestry setting, community participation and involvement is very active in both selection/improvement and conservation of genetic resources of crops and trees. The practices could be driven by economic reasons or other reasons, such as religious influences. While in a more modern situation, usually in a government initiated programs, several levels of participation can be found. From the observation so far, traditional systems' improvement and conservation effort can be a sustainable and promising option. Meanwhile the present government has also started to develop more participatory programs with a view to decentralization of this issue. This paper will illustrate the state, and discuss development of participatory improvement and conservation of genetic resources in several areas of Indonesia.

Analyzing plant breeding theory in the context of collaboration with farmers: Genotype by environmental interaction and wide vs. narrow adaptation

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The question of whether plant breeders should aim for widely or narrowly adapted crop varieties is an important and controversial one in plant breeding, and has important implications for working with farmers. We analyze the choice between widely and narrowly adapted crop varieties in plant breeding by both scientists and farmers in terms of management of genotype-by-environment interaction. We use a framework for understanding plant breeding based on a holistic model of human knowledge and the basic biological model of plant breeding. Data are from interviews with farmers and plant breeders and an analysis of the literature. Differences in emphasis on wide v. narrow adaptation appear to be influenced both by social (values underlying definitions of sustainability and yield stability) and biophysical (differences in the range of genotypes and growing environments experienced) factors. The results suggest that this framework can be used to understand differences and similarities among plant breeders and among farmers, and between plant breeders and farmers, that are critical to the success of collaborative plant breeding.

Farmers' knowledge as a conceptual component of collaborative plant breeding

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Collaborative plant breeding (CPB) has been suggested as a method to more effectively address biological and sociocultural needs not met by conventional plant breeding. The potential of CPB, however, can only be evaluated when the contributions of both farmers and plant breeders are understood and used in the process. Farmers' contributions to CPB have often been assumed to be descriptive or discriminatory, for example, identifying preferred (or rejected) varieties, lines, or selection criteria. The theoretical basis of farmers' knowledge of their crop populations and growing environments has rarely been considered in CPB, yet may be important for experimental design, choice of germplasm, opportunities for substantive collaboration, and determining the educational needs of farmers and plant breeders. A methodology has been developed to elicit the theoretical bases of farmers' choice of varieties and populations for specific environments, and for seed selection practices, and is now being applied in research with maize in Mexico and with barley in Syria. Results to date have elucidated farmers' perceptions of heritability, their own selection methods, spatial and temporal GEI, risk and yield variability, and population structure and segregation. Future work at these sites will test the methodology with more farmers and will be expanded to farmers in other regions cultivating different crop species. This work will also be exploring interdisciplinary collaboration among outside scientists to make use of these findings for improving the efficacy of CPB. Methodologies such as this may contribute to realizing the potential of CPB, thus providing a more accurate test of CPB as compared to more conventional plant breeding approaches.

Scientific preparation for collaboration: On-going work with simulations of stratified mass selection

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Collaborative plant breeding (CPB) often assumes that technical advice by scientists indicates the most effective means to achieve genetic advances. Given this assumption, lack of farmer interest or involvement would be interpreted as a failure of farmer collaboration. This study takes the perspective that enough may be different biologically and/or socioeconomically in a CPB context compared to more conventional plant breeding ones that lack of collaboration could be due to inappropriate technical approaches, among other things. This may be especially true for methods intended for direct use by farmers such as on-farm stratified mass selection (SMS), where selection is conducted independently within sub-blocks of a farmer's field. Such methods do not follow experimental design protocols familiar to many plant breeders, and few conceptual or practical guidelines exist for their testing and application in CPB. The purpose of this ongoing research is: 1) to investigate possible outcomes of forms of on-farm selection including a number of independent variables (gene frequency, temporal V_E, structure of spatial V_E, genotype-by-environment interaction (GEI), choice of traits, selection strategy), and, 2) to determine if simple guidelines can be developed for optimizing on-farm selection. Elementary spatial statistics will be used to quantify and distinguish broad classes of within field spatially structured V_E. QUSMS, a new module for the genetic simulation program QU-GENE, simulates both stratified and mass selection with different genetic and environmental models and uses information on spatial variation within fields. Simulation findings to date suggest generalization on the relative performance of stratified and mass selection may be difficult as a number of factors—some of them interacting—can have a significant effect on selection outcomes. Still, for the same trait heritability and temporal V_E, some patterns are emerging relating to frequencies of within-field subenvironments, type of GEI present, and starting frequency of favorable alleles. For example, a relatively higher performance was observed for SMS than mass selection for scenarios where GEI were of the cross-over form and the highest yielding suben-

vironment was also the least frequent in the field. However, in numerous scenarios mass selection outperformed SMS, particularly when the highest yielding subenvironment dominated the field.

Farmers and informal sectors in enhancing biodiversity and production through participatory plant breeding

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Participatory plant breeding (PPB) together with seed exchange has been shown to increase productivity and strengthen the process of on-farm conservation through participation of farmers. Participation by farmers and informal sectors in decentralized testing of materials can result in much greater diversity in the fields of collaborating farmers, provide a broader range of varietal choices to growers, and enhance adoption level. Germplasm exchange between farmers can contribute and enhance on-farm conservation and biodiversity. Within the IPGRI-supported project "Strengthening the Scientific Basis on *In Situ* Conservation of Agricultural Biodiversity", case studies were made in rice and taro in Nepal and Vietnam on consolidating the roles of farmer participation in PPB and seed exchange processes. Participatory methods such as diversity fairs, diversity blocks, and community biodiversity register were used to understand the process of farmer decisions influencing management of local crop diversity.

Participatory plant breeding projects were investigated to identify whether (1) farmer's cultivars *per se* were being conserved, (2) PPB contributed to the enhancement of biodiversity in terms of a broaden genetic base that provided benefits to the community, and (3) genetic improvement was being achieved without loss of genetic diversity. The paper then discusses modes of participation in PPB and seed exchange and the need to measure the impact of these interventions in terms of the change in average, weighted average and temporal diversity over time at the village, community and agro-ecosystem levels. The paper also documents how the needs of farmers and NGO are integrated into the setting of breeding goals and supplying useful genetic diversity through bringing new, restoring old and generating new genetic diversity (local x exotic) in the agro-ecosystem. Methodological constraints of choosing parents for biodiversity enhancement and production objectives in biodiversity rich areas are discussed.

A case study in participatory plant breeding in rice. III. High potential production systems in Nepal

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When a breeding program is based on a few crosses, the choice of parents is crucial. A participatory plant breeding (PPB) program is described for February-sown (*Chaite*) rice in a high potential production system in Nepal. Kalinga III, an early duration upland rice variety from India, was identified as being suitable for *Chaite* in areas with limited irrigation in a participatory varietal selection (PVS) program. Kalinga III, has been used as a parent to breed superior varieties for the small target area—the least favorable environments in this high potential production system where irrigation water is limited—to which this variety is adapted. We describe the modified bulk population and pedigree bulk methods that have been employed in this cross. Consultative participation was effective in eliminating entries before collaborative participatory trials were undertaken. A program of collaborative participation using F_4 and F_5 bulk populations over a range of altitudes in favorable irrigated environments is described.

PPB methods have also been used in a mutation breeding program for Basmati rice. First, participatory varietal selection was employed to identify target traits. Collaborative and consultative participatory methods were then combined to identify promising lines in a mutation breeding program based on variety Pusa Basmati 1. From the results of participatory rural appraisals and PVS, further crosses were chosen to target the largest agro-ecological niches of the *Chaite* and main seasons. Progress and methods, either doubled haploid or modified bulk population methods, in these crosses are described.

Managing genetic diversity of maize in small farming communities of Brazil under stress conditions

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In Brazil, as in the tropics in general, crops are frequently under stress due to low soil fertility, floods or drought. Over 70% of the maize crops in Brazil are under these conditions. To overcome this problem, scientists in the tropics are looking for different sources of genetic variability that allow local varieties to grow and produce crops under stressing environments. Together with improved soil management and participatory plant breeding, this material can import a sig-

nificant improvement for tropical agriculture. In Brazil, in 1990, Embrapa (Brazilian Agriculture Research Corporation) and non governmental organizations (NGO's) working with small farmers have begun a joint effort to collect, characterize, improve and multiply those local varieties of maize.

From 1990 to 1992 40 local varieties were selected. From 1992 to 1993, 49 maize varieties, among them 35 local, 10 improved and 2 hybrids were characterized for its tolerance to N and P stress. In the 93/94 growing season, 36 plants were tested for low pH (5,0), 27 were local varieties, 7 were improved varieties and 2 were hybrids. In the 94/95 growing season 16 varieties were selected from the previous trials, those were 12 local varieties, 3 improved varieties and 1 hybrid. The selection processes were run in 6 different locations low in P and N. During the selection, emphasis was given to the participatory process. It was found that local varieties selected by the farmers themselves could match the improved varieties for its productivity, besides being tolerant to environmental stress. Participatory plant breeding was also used to bred two new varieties "Sol da Manhã NF" and "Sol da Manhã ND". These plants were characterized as high yielding, and efficient in the use of N and P. This suggests participatory plant breeding as a new paradigm for breeding maize plants for tropical environments under nutritional stress.

Changes in rice biodiversity and responses of community and local governmental coastal agroecosystems of Hue Region, Central Vietnam

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The interests in on-farm conservation become greater with the community roles and actions because the current traditional cultivars being maintained are not objective at all to the formal ago-supporting systems. Using data collected at different time (in 1996 and in 2000) on farmers' management of rice varieties, the paper demonstrates the dynamics changes in rice biodiversity on-farm at household and village levels in marginal coastal agroecosystems of Hue region, Vietnam. Total number of rice varieties being used for Winter-spring and Summer-fall growing seasons increased at both the household and village levels. However, the proportion of traditional cultivars in total number varieties was reduced. Similarly the distributions of traditional cultivars, measured by number of planted households, was decreased. Among the observed causes of the changes was referred to the century catastrophic flood (in November 1999) which damaged seeds and destroyed the seed infrastructure of majority of the farmers in the areas. The responses of the farmers, farming community and local government to current situation are described to understand how these effected the rice biodiversity.

The discussions in paper are to highlight the importance of the farmers and community in taking active roles for on-farm conservation, especially for maintaining the traditional cultivars. However, the vulnerability of seed infrastructure of the farmer household and the community constraints their activeness from the roles and responsibilities assumed. The challenge in strengthening the farmers and community seed infrastructure is to integrate it into formal agro-supporting systems, particularly the seed supply systems at locale. It is essential that the supporting policies and services take the farmer preference to varieties into account to favor the on-farm conservation of rice biodiversity.

Socio-economic framework for *in situ* conservation: A case study from the Sierra Norte de Puebla

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This paper proposes an economic framework for the *in situ* conservation of crop genetic resources (CGR). Its starting point is not the valuation of CGR, but the understanding of the contexts of where and when CGR are conserved. Its purpose is to inform and aid the implementation of conservation programs. It is inclusive, but not exhaustive, and it emphasizes local conditions and history over general theory. The McKnight-MILPA project in the Sierra Norte de Puebla (SNP) is used as a case study, and preliminary findings are outlined, including potential impacts of its participatory improvement of local crop varieties.

The framework focuses on the evolutionary and dynamic contexts of CGR management as planted, selected, and adapted in farmers fields, and addresses four main areas: i) household consumption/production decisions and constraints; ii) household behavior regarding seed selection and exchange; iii) households' interactions in local staple, labor and land markets, and iv) scope and scale issues related to moving from household to community to regional analysis.

Milpa competes for land and labor with coffee wherever this grows in the SNP, but milpa remains important for many households. At the regional level, heterogeneity in development produces a few areas of high varietal diversity. Within these areas, at the village level, diversity decreases with market integration and as migration spreads. For individual households, the trend is toward a reduced number of varieties, with local white maize predominating and a minimal presence of improved varieties. Market development may not promote conservation, especially given the large inflow of maize into the region. Participatory breeding is bound to decrease the region's maize deficit, but its effect on landrace diversity will depend on local land and labor markets. Given the theoretical framework and empirical study of the region, policies can be implemented region-wide, or they can target individual households, villages, or varieties.

Response to selection in Mexican landrace populations of squash (*Cucurbita* spp.) derived from farmer-scientist collaborative plant breeding

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In Mexico, production of squash *(Cucurbita* spp.) based on improved varieties is restricted to a few highly capitalized, irrigated areas. Instead most production relies on locally adapted landrace varieties grown under rain-fed conditions, typically in a maize-based intercrop. In recognition of a lack of governmental squash breeding programs, in 1996 a set of on-farm, participatory breeding projects targeting local landraces was initiated with a grant from the McKnight Foundation. The work involves cooperation between researchers at the Universidad Autonoma Chapingo (UACh), Iowa State University, and farmers in three states in central Mexico. The on-farm work is complemented by landrace breeding projects conducted *ex situ* in UACh experiment station plots. Four species of *Cucurbita (C. argyrosperma, C. ficifolia, C. moschata,* and *C. pepo)* are under mass or combined family selection. By 2000, populations were in their third to fifth selection cycle. The methodology developed utilizes an experimental design of 2 ha plots of squash inter-cropped with maize, with selection pressure of 15% implemented in the field and 5% post-harvest. Selection criteria implemented in the field include earliness, plant health, and fruit size, color, texture, and yield, while that implemented post-harvest includes seed yield and fruit flesh quality traits. In the study regions, the criteria considered desirable for improvement of squash varies depending on the cooperating farmer; likewise the commodity of importance varies (e.g., seeds, immature fruit, mature fruit, flowers). For the majority of the populations, the frequency of fruits with more intensely dark fruit flesh colors (considered desirable) has increased notably during the cycles of selection. The fruit flesh flavors rated favorably as sweet or very sweet have increased slightly to strongly in frequency in most populations, but stayed the same or decreased in others. With some exceptions, a positive response to selection has been found for the quantitative traits under study, although the magnitude has varied widely (1.0 to 201.6%).

A case study in participatory plant breeding in rice. II. Marginal environments in Eastern India

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We describe a participatory plant breeding (PPB) programme for rice in eastern India targeted predominantly at the upland rice ecosystem. Only a few crosses with large populations were used and all the crosses involved Kalinga III as a parent. Kalinga III is the most widely grown upland rice variety in India and is grown by many farmers in the target areas of Bihar, Orissa and West Bengal. Consultative participation was used to the largest extent by bringing farmers to the research station to evaluate F_4 pedigree bulk lines. The methods and results from this consultative selection are compared with the results of selection by breeders. Some farmers were given tall bulks of the cross on which to carry out selection in their own fields. In one case, this resulted in a promising variety subsequently named Ashoka F200. How farmers have dealt with variable bulks in their own fields is described, and the general applicability of this collaborative approach is considered.

The performance of the most promising entries in both formal and participatory trials is described. Evidence, so far, indicates that this participatory breeding program, has produced varieties rapidly that significantly out-perform Kalinga III for grain yield and straw strength, whilst retaining the desirable earliness and grain type of Kalinga III. Other strategies have been used and are described. These include modified bulk population breeding to provide heterogeneous and homozygous bulks to farmers for selection.

A case study in participatory plant breeding in rice. I. Theory of participatory plant breeding and the use of marker-assisted selection

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Theory on the optimum number of crosses in inbreeding crops such as rice is briefly reviewed. The theory is unsatisfactory in determining the optimum number of crosses but, when linkage is considered, very large populations are needed to recover specified genotypes. Although breeding programs commonly use many crosses this is determined by the economic environment. For private-sector companies it is insufficient to produce a variety better than the one farmers are currently growing—only a variety that is better than those of competitors will suffice. Hence, most breeders attempt to make the very best cross, at the inevitable expense of population size. In other economic environments, e.g., public sector organizations using centralized breeding to

target large areas, the best parents are difficult to identify so many crosses are made. In decentralized breeding, the agro-ecological zone and the socio-economic client group are very well defined and choosing parents is simpler. It is often rendered even simpler by a non-competitive environment that only requires producing a variety that performs better in the target environment than the one farmers are currently growing. Fewer crosses can be used, all of which are considered promising—such crosses almost inevitably involve a popular variety in the target area. Each cross is more likely to succeed because selection is in the target environment.

A low cross number is ideally suited to participatory plant breeding (PPB) where the number of entries is more constrained than population size. Breeding strategy, however, is determined more by decentralization than participation, and within the participatory element consultation may be more important than collaboration. Modified bulk population breeding methods are desirable strategies in PPB in rice. Decentralized, participatory breeding programs for rice in India and Nepal is described in papers two and three of this series. Participatory, decentralized approaches are compatible with high technology approaches. We describe how we are using molecular-marker-assisted selection, in a decentralized, participatory breeding program, to introduce improved root traits and aroma into Kalinga III from rice cultivar Azucena.

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